Final Project Report

Office of Naval Research

AASERT Grant

Variability of the Circulation in the European Polar Seas

Award Number N00014-93-1-0830

Peter Schlosser
Principal Investigator

6/1/93 – 5/31/96

1. Background

During the past two decades we created a substantial transient tracer database (mainly tritium and ^{3}He) for the European Polar Seas (Greenland/Norwegian seas and Eurasian Basin of the Arctic Ocean). Our primary goal was to study formation rates, pathways and mean residence times of the deep waters in these basins. Evaluation of the tritium/^{3}He time series for the Greenland Sea Deep Water spanning the period between 1972 and 1988 yielded the surprising result of a drastic reduction in Greenland Sea Deep Water formation from about 0.5 Sv to 0.1 Sv starting around 1980. On the other hand, this drastic change produces only a very small hydrographic signature of the order of 0.005 psu and 0.1°C which is not large enough for quantification of the change of the deep water formation rate. Therefore, tracer studies are a unique tool for studies of variability of ocean circulation on a time scale of several years to several decades.

Our initial focus was on quantification of variability of Greenland Sea Deep Water formation because this water mass is fairly homogeneous and is relatively well sampled. In the framework of this AASERT grant we planned to extend the evaluation of our tracer time series to the shallow water column of the Greenland Sea and to other basins of the Eurasian Polar Seas (Norwegian Sea, Arctic halocline, etc.). The grant provided funds a graduate student (Brenda Ekwurzel) to study the change in the Arctic halocline observed during the 1990s. Brenda Ekwurzel obtained her PhD degree in 1998.

2. Sample collection

Part of the work performed by Brenda was related to collection of new data sets in the Arctic Ocean, specifically the Canadian sector. These samples provided the basis for her thesis.

3. Measurements

Brenda participated in the measurement of several large data sets. These measurements were funded through several ONR and NSF grants. The tritium and helium isotope data were measured at the L-DEO Noble Gas Laboratory (NGL). The sample quality was very good and consequently the data set is of high quality. The ^{18}O samples were measured in the stable isotope laboratory of Rick Fairbanks at L-DEO. Again, we obtained a high-quality data set. Finally, the ^{14}C samples were measured at the WHOI AMS facility at a precision of about ±3 to 5‰.

4. Results

The main results of the study were summarized in the PhD thesis of Dr. Brenda Ekwurzel (defense: 1998; Ekwurzel, 1998). They are related to the following issues:

1. Determination of the fractions and water column inventory of the individual freshwater sources contributing to the Arctic surface waters (river runoff, sea-ice meltwater, Pacific inflow. Specifically, we were able to develop a better procedure for visualization of the Pacific freshwater component in the surface waters of the Canadian Basin (Ekwurzel et al., 1998).

2. Description of the variability in the properties and composition of the Arctic halocline (Ekwurzel, 1998). This was the main topic of the AASERT supported piece of Brenda's work.

3. Determination of the mean residence times of the surface waters and the Atlantic waters in the Canadian Basin (Ekwurzel et al., 1998).

4. Description of the sea-ice formation/melting cycle on the shelves of the Arctic Ocean (Ekwurzel et al., 1998).

5. Derivation of the mean residence times of Canadian Basin Deep Water (Schlosser et al., 1997).

The results contained in Ekwurzel (1998) are presently being prepared for publication. We are in the process of finishing three manuscripts for submission to JGR and DSR.

Reference

Ekwurzel, B., Arctic Ocean water mass circulation and ventialtion ages derived from tritium, helium, and oxygen-18 tracers. Ph.D. Thesis, Columbia University, May 1998.

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Peter Schlosser

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Lamont-Doherty Earth Observatory
Route 9W
Palisades, New York 10964-8000

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13. ABSTRACT (Maximum 200 words)

Our primary goal was to study formation rates, pathways and mean residence times of the deep waters in the basins of the European Polar Seas. Evaluation of the tritium/^{3}He time series for the Greenland Sea Deep Water spanning the period between 1972 and 1988 yielded the surprising result of a drastic reduction in Greenland Sea Deep Water formation from about 0.5 Sv to 0.1 Sv starting around 1980. However, this drastic change produces only a very small hydrographic signature of the order of 0.005 psu and 0.1°C which is not large enough for quantification of the change of the deep water formation rate. Therefore, tracer studies are a unique tool for studies of variability of ocean circulation on a time scale of several years to several decades. Our initial focus was on quantification of variability of Greenland Sea Deep Water formation because this water mass is fairly homogeneous and is relatively well sampled. In the framework of the AASERT grant we planned to extend the evaluation of our tracer time series to the shallow water column of the Greenland Sea and to other basins of the Eurasian Polar Seas.

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